Transparent Urban Structures
Enabling Capability Program
BAA 06-024
Industry Day

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Office of Naval Research

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Intelligence Report - 22 Main Street
Aerial Photo:

Blue Print:

Intelligence Reports:
HUMINT: xxxxxxxxxxxxxxxxxxxxx
OSINT: xxxxxxxxxxxxxxxxxxxxx

Activity Characterization:
xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx
Xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx

Transparent Urban Structures (TUS)

Collect, Understand, and Disseminate Intelligence for the Close-in Urban Fight

Urban Situational Awareness
Actionable Intelligence

- Determine Intent of Structures:
  - Detect and classify threats inside buildings and underground
  - Map the urban terrain in three dimensions, inside and out
- Process the data to make it understandable and actionable
- Get the right data to the right user quickly

Make urban man-made structures transparent

Outline

- ## Introduction
  - Military Needs
  - Challenges

- ## Transparent Urban Structures Defined
  - Focus of ONR Effort
  - Needed Technology

- ## Program Organization

This program builds upon and is complementary to the DARPA VisiBuilding and Army CERCEC-I2WD STTW Programs

Focus

- Expeditionary unit focus
    - Marine Corps
    - SOCOM
    - Navy Expeditionary Combatant Command
- Relevant to:
    - Global War on Terror
    - Distributed operations

Sense Through Structures (STS)

- "…STS technology will allow the warfighter to become more proficient at operating in the difficult and complex landscape of cities and minimize the advantages conferred to the enemy operating in urban terrain…"

- "…a STS capability improves both tactical and operational effectiveness in the Joint functional areas of Battlespace Awareness, Force Application, and Force Protection."

  - USJFCOM Joint Urban Ops Office, May 2006

- 4th Infantry Division Operational Needs Statement
- U.S. Army Training and Doctrine Command (TRADOC), *2005 Capability Gap Analysis*
  - Current Force Capability Gap Area 7 (Ability to conduct Joint Urban Operations)
- *U.S. Marine Corps Expeditionary Maneuver Warfare Capabilities List*
  - Develop capability to detect and classify personnel within urban structures to include buildings, basements, sewers and subterranean complexes
- U.S. Air Force Master Capabilities Library, Version 5.5 Final
- National Institutes of Justice (NIJ), *Solicitation for Sensor and Surveillance Technologies*

- USJFCOM Joint Urban Ops Office, May 2006

- Standoff target detection through very thick walls, solid metallic walls, metallic substructure, or walls lined with radio frequency (RF) shielding

- Through wall personnel classification and identification

- Through wall detection of hazardous and explosive materials

- Large field of view 3D localization and mapping from stand-off ranges
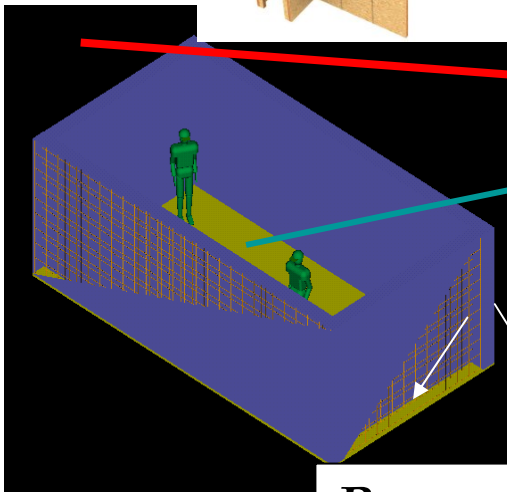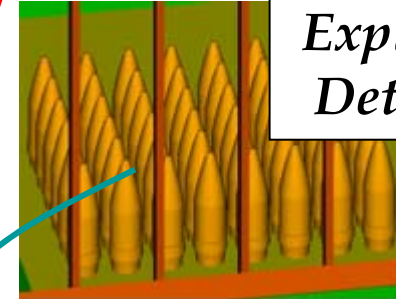
- Data dissemination and networking of STS systems
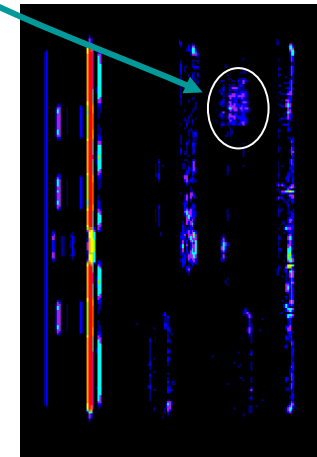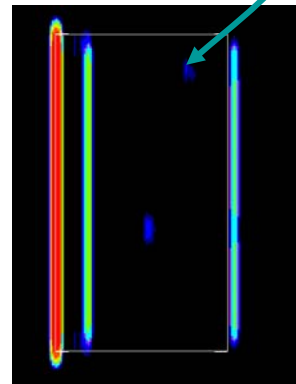
- USJFCOM Joint Urban Ops Office, May 2006

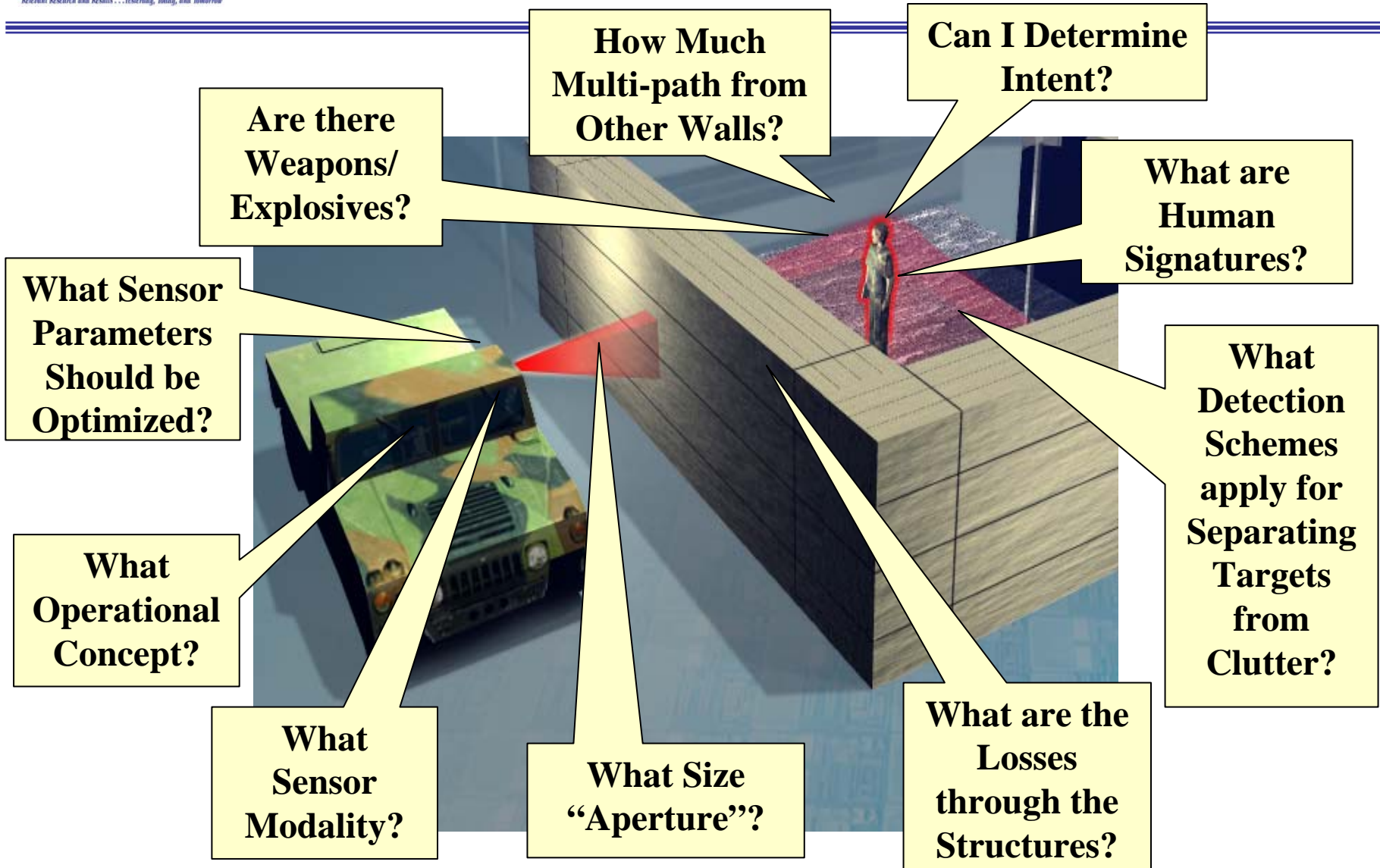**Man-made Structure Classification, Mapping**
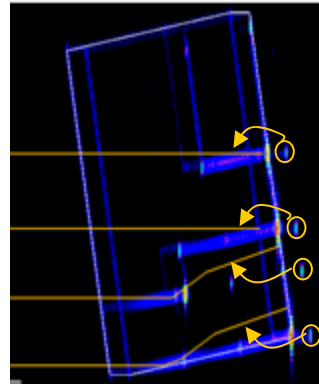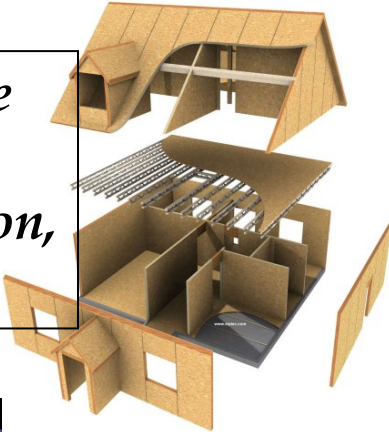
Weapons/ Explosives Detection

Personnel Location and Intent

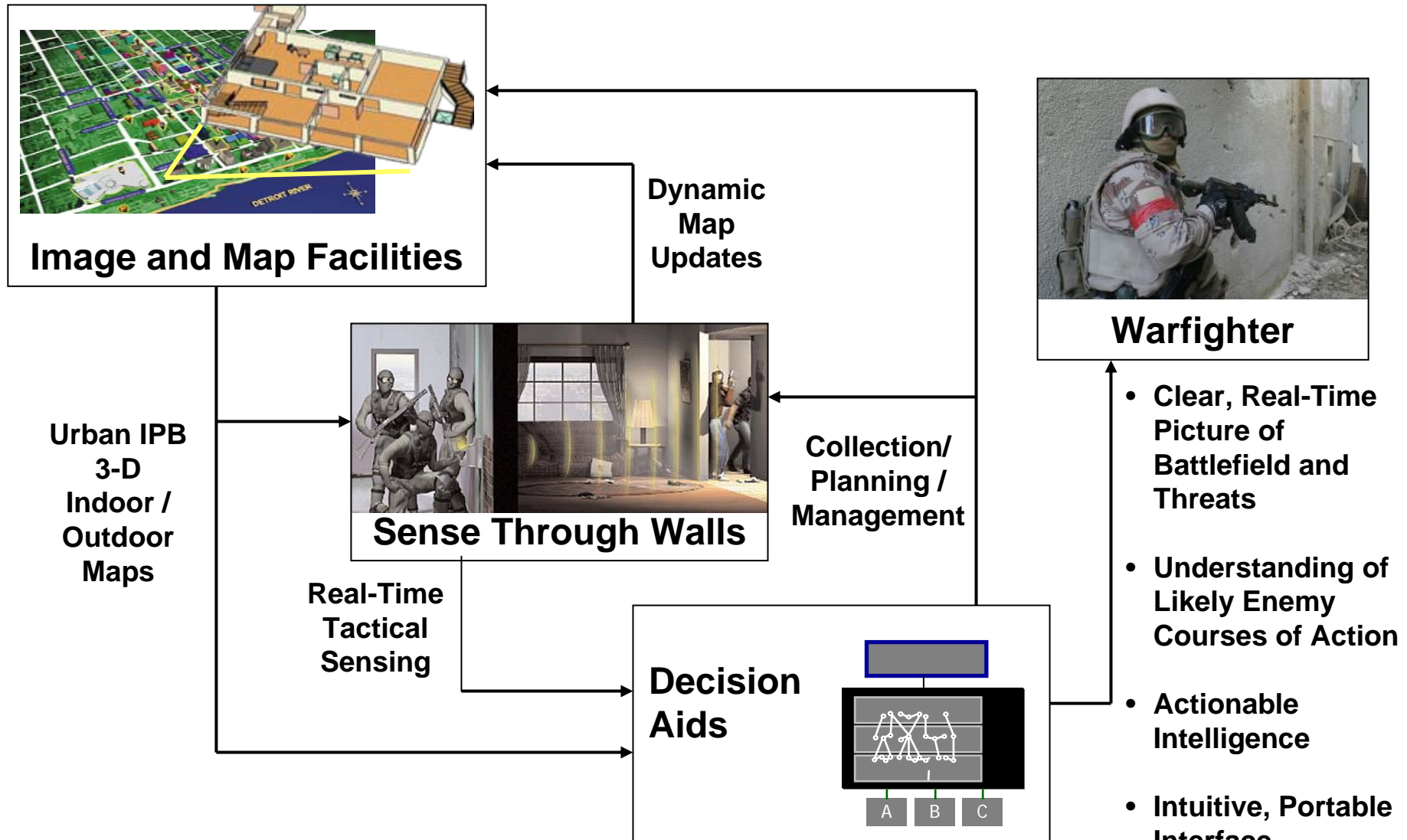**Actionable Intelligence Enabled by Data Fusion**

- Determine *intent* of man-made structures
- Understand phenomenology to guide sensor development
- Develop sensors *agile* in modality, polarity, operating bands, waveforms (portable, unattended, UAV and vehicle mounted)
- Develop systems for standoff detection of weapons and/or explosives (including precursors) caches within structures
  - Open to alternative sensing approaches, not just RF
- Develop systems for standoff detection and location of humans within man-made structures
  - Determine intent of personnel detected, e.g. co-located with weapons (static and dynamic)
  - For stationary personnel can use human signature analysis, biometrics, high resolution
- Detect and map underground structures, quickly map above ground structures
- Deliver the right image to the right Marine at the right time – tailored to mission needs
- Use data/Intel context to produce actionable intelligence

How Much Multi-path from Other Walls?

Can I Determine Intent?

Are there Weapons/ Explosives?

What are Human Signatures?

What Sensor Parameters Should be Optimized?

What Detection Schemes apply for Separating Targets from Clutter?

What Operational Concept?

What Sensor Modality?

What Size "Aperture"?

What are the Losses through the Structures?

- ## Sense Through Walls
  - Sensor development informed by phenomenology

- ## Image and Map Facilities
  - Hardware and algorithms for 3D mapping of man-made structures

- ## Decision Aids
  - Planning, analysis and visualization technologies for penetrating sensors

Product Relationships

Image and Map Facilities

Dynamic Map Updates

Warfighter

Urban IPB 3-D Indoor / Outdoor Maps

Sense Through Walls

Collection/ Planning / Management

Real-Time Tactical Sensing

Decision Aids

A B C

- **Clear, Real-Time Picture of Battlefield and Threats**

- **Understanding of Likely Enemy Courses of Action**

- **Actionable Intelligence**

- **Intuitive, Portable Interface**

Sense Through Structures

- Understanding of phenomenology to guide sensor development

- Sensors agile in modality, polarity, operating bands, waveforms

- Standoff detection of weapons and/or explosives caches within structures

  - Open to alternative sensing approaches, not just RF

- Standoff detection, location and classification of humans within man-made structures

- Create a 3-D imaging and mapping database of urban region of interest

    – Incorporate all forms of intelligence

    – Support optimal positioning of sensor

    – Output is registered IMINT/MASINT interoperable data

- Develop sensors to detect and map above and below ground structures capable of high throughput

Enabling Net-Centric Warfare (Refresher)

- To enable net-centric warfare a net-centric enabling environment must exist
- Core capabilities of a net-centric enabling environment
  - Ability to communicate with any object
  - Can share/access data, information, knowledge with any object
  - Objects
    - Warfighters
    - Distributed data sources
    - Applications/services
    - Visualization
    - Alerts

…Power to the Edge!

Decision Aids

- Translate data generated STS and multi-INT data into a family of tactically relevant products using available context where applicable.
- Development of algorithms that process STS data to determine building intent
  - Incorporate all forms of intelligence
- Intuitive interfaces providing actionable intelligence
- Provide mechanism for sensor planning and management

"… users felt the systems slowed their momentum in clearing operations, left them vulnerable during use, and were in some cased difficult to interpret …"

- USJFCOM Joint Urban Ops Office, May 2006

Phenomenology

- Phenomenologies to be understood include:
  - interactions among the illumination source, objects of interest, and sensor
  - propagation characteristics of signals through diverse media
  - impact of background noise
  - near-field effects
  - dispersive and scattering losses
  - multipath
- Sensing systems considered for this program must be developed in light of a fundamental phenomenological understanding of the selected modality
- This program places particular emphasis on a critical examination of sense-through-wall phenomenology for systematic development of agile sensor modalities and algorithms

Detecting and locating the presence of hostile forces in urban settings poses significant technical and operational challenges.

Squad carrying cooperating sensors

Robotic ground vehicle sensor

Unmanned air vehicle sensor
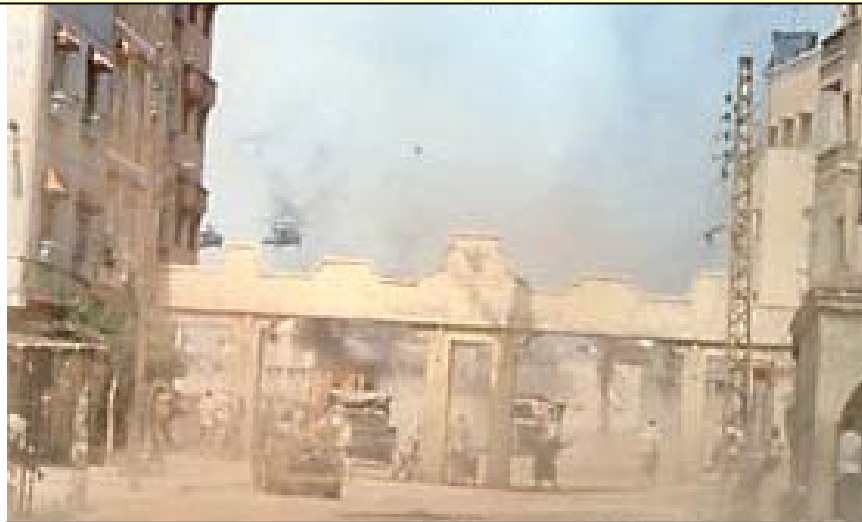
Unattended sensor

**Where is the enemy?
How do I find them and their armaments?**
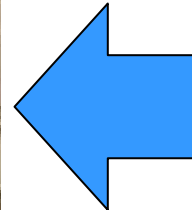
Sensor Agility

- Sensors should be agile to dynamic warfare conditions by having the ability to modify their parameters to enhance sensing sensitivity
- Agility here assumes the ability of the sensor to modify in real time its parameters and include but not limited to:
  - Modality
  - Number/type/position of sources and detectors
  - Polarity
  - Operating bands and wavelengths
  - Waveforms
- Questions on agility offerors should answer include:
  - How should sensor agility be utilized to exploit the phenomenology of the scene adaptively in order to achieve high image resolution and understanding?
  - For a particular modality, what sensor settings can and should be changed at each iteration of scene optimization?

Sensor Modalities

- Suite of sensor modalities and fusion of multi-modality data may be considered
- A suite of sensors may be a collection of different sensing modalities and may include but not limited to:
    - radio frequency (RF)
    - gamma-ray, x-ray, neutron
    - acoustic, seismic, electrostatic, gravity
    - terahertz (THz)
    - thermal, optical
- Active or passive
- System form factors (size, weight, and volume) should be consistent with the maturity of the underlying modality considered

Regardless of the proposed system's targeted platform the system should demonstrate potential for transition to expeditionary forces

Platforms

- STS platforms included but are not limited to
    - Unattended
    - Hand-held
    - Small UGV-mounted
   - HMMWV-mounted
    - UAV-mounted

Human Targets

- Moving and stationary personnel detection, geolocation and classification within man-made structures can be performed with any promising method including:
  - Doppler
  - Human signature analysis
  - Biometrics like respiration, "EKG", posture sway
- Differentiation of animate from inanimate objects and human from non-human is highly desirable
- Use of unattended sensors, left behind to report intelligence covertly, should be considered

Challenge of Detecting Stationary Personnel

WITHOUT METAL FURNITURE

WITH METAL FURNITURE

Down range resolution = 3"; Cross range resolution = 5"
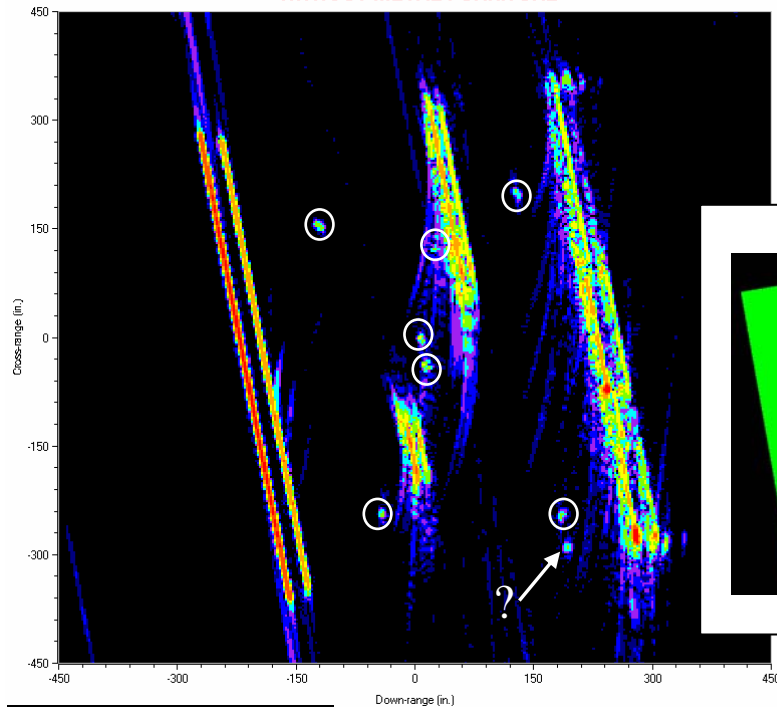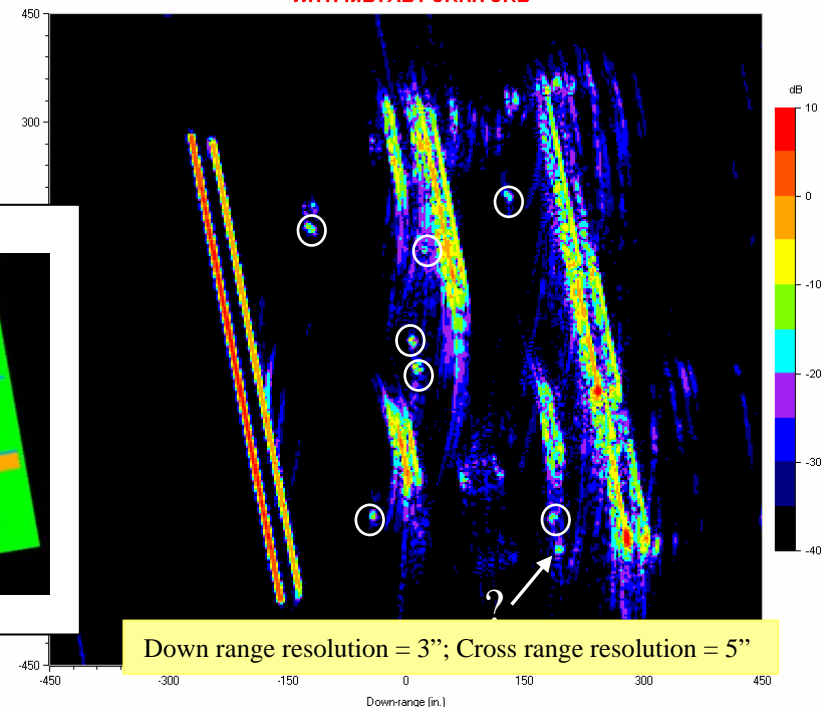
O Target locations

Xpatch simulations by ARL
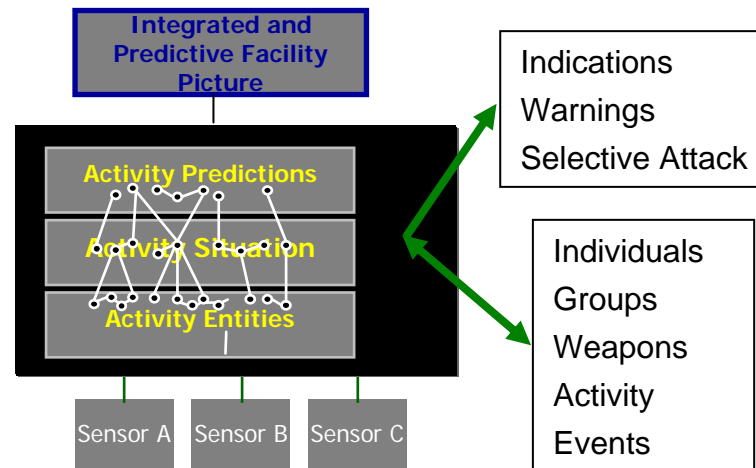
Building Understanding

- Systems may have the capability to identify construction features in a means relevant to expeditionary units including:
  - walls, windows, stairwells,
  - provide three-dimensional map of structures
- The capability to detect the presence of underground structures such as sewers, building-to-building connections, and basements is highly desired

Passive STS

- Passive detection/classification systems that exploit inherent illumination of a geographic region by, for example cellular and satellite communication infrastructures, to obtain context of building usage and intent

- Fuse all available information relating a particular structure of interest.

- STS content from ground sensors will be cohered with content obtained from airborne sensors and other intelligence sources.

Material Understanding

- Detection, geolocation and identification of materials of interest (weapons including hand-held firearms , explosives caches, precursor chemicals of interest)

  - Potential methods for identifying weapons include high-resolution imaging from multistatic geometries providing angle diversity and pulsed ultrawideband sensors
  - Signature-detection methods of chemical, spectral, or nuclear may provide ways to pinpoint the presence of concealed weapons

- Offeror can choose platform (portable, unattended, vehicle or UAV mounted)

- Solutions must be tactically relevant to expeditionary warfare

Intent

- Systems should perform behavior and activity classifications by determining intent of personnel detected within structures

- Intent can be understood by proximity of detected personnel to armaments or weapons/explosives caches, by dynamic behavior classification or by association with prior information/knowledge

Building Intent Background

- In support of repetitive crime, such as the insurgent attacks associated with the war on terror, responsible hostile actors need to leverage supporting facilities.

- To sustain their hostile behavior bad actors (insurgents, serial killers, drug dealers, etc.) need places from which they can train, plan, store material or simply sleep.

- The urban clutter affords considerable concealment for the actors that must be captured.

- The ease with which their supporting facilities can blend into the clutter further complicates the task of finding civilian distributed hostile networks.

- Novel capabilities are needed to aggregate and classify facilities, develop facility network diagrams and ontologies that relate details about a facility (e.g. location, size, floor plans, intended use, references in HUMINT or open source data, etc.) to hostile actions via the decision preference factors of the hostile actors.

- The required analysis engine must be dynamic, allowing new data sources to be continuously used to improve predictions and detect changes in past patterns.

- The Building Intent initiative will provide near real time data prediction tools that will aid in shutting down facilities that support repetitive hostile action.

- A building classification inference can be the fused product of:
  - Geographic profiling
  - Building feature and or activity correlation to events of interest

- What data sets are required to classify and network urban structures?
  - Aggregation of like facilities
  - Association of groups of facilities that collaborate
    - Facilities used for planning connect to facilities used to quarter hostiles which connect to facilities used for material storage

Actionable Intelligence

- All sense-through-wall intelligence is processed to convert raw data into optimum own-course-of-action decisions

- A suite of decision aids are to be developed to enhance inter-operability, visualization, interpretation/analysis, and sensor planning and management

- In addition these algorithms will perform positive identification of targets and determine whether targets are armed, automatically generate indications and warnings, detect "seen but unobserved" behavior, and disseminate content to an intuitive, three dimensional situational awareness tool

- The critical objective is to propagate in real time the appropriate information to all levels of command from warfighter to commanders

A system that provides an integrated capability is preferred

But…

Partial Solution

- Offeror may submit a separate proposal for one or more of the three thrust descriptions
- Partial solutions will be considered:
  - Determine *intent* of man-made structures
  - Understand phenomenology to guide sensor development
  - Develop sensors *agile* in modality, polarity, operating bands, waveforms (portable, unattended, UAV and vehicle mounted)
  - Develop systems for standoff detection of weapons and/or explosives (including precursors) caches within structures
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  - Use data/Intel context to produce actionable intelligence
- Offerors of partial solutions need to specify clearly how system addresses the overall goal of determining the building intent and classifying activity within buildings

Of note…

"…In addition, it should include a Statement of Operation Utility that clearly states what the proposed effort does for the warfighter "

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White Papers Due – 27 July 2006

Email your question to:

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